Progress Report - 10

Cropping Systems (Entomology)

Cropping Entomology

Report of Work

1982-83

C.S. PAWAR

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

ICRISAT Patancheru P.O.

Andhra Pradesh 502 324, India

This report has been prepared to share the information that we have gathered in this year, with other scientists who have an interest in cropping systems entomology work.

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CROPPING SYSTEMS ENTOMOLOGY STAFF 1982-83 AND COLLABORATING SCIENTISTS

AGRONOMIST (SUB-PROGRAM LEADER)

Dr R W Willey

ENTOMOLOGIST

Dr C S Pawar

RESEARCH ASSOCIATE

Mr D R Jadhav

FIELD ASSISTANTS

Mr G Venkateswarlu
Mr M A Lateef
Mr K A Chari
Mr N Narayana

STENOGRAPHER

Mr Y M Prasada Lingam

DRIVER-CUM-GENERAL-ASSISTANT

Mr R Venugopal

COLLABORATORS

ENTOMOLOGISTS

Dr W Reed
Dr S Sithanantham
Dr H C Sharma
Dr P W Amin

PATHOLOGIST

Dr J Kannaiyan

PLANT PROTECTION

Mr S K Pal

ENGINEER

Mr. R K Bansal

AICPIP

Dr J N Sacchan, Principal Investigator (Entomology) IARI, Kanpur

OFFICERS OF THE DEPARTMENTS OF AGRICULTURE WERE ALSO COLLABORATORS FOR ON-FARM RESEARCH

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The Cropping entomologist wishes to thank further all his dedicated workers who did the work in a team spirit.

GENERAL

This year, we concentrated much of our efforts on on-farm research to help the farmers in effective and economic pest management in their crops, which they grew under the Vertisols watershed technology scheme taken up by the Indian state-governments with the help of ICRISAT. We monitored pests and parasitoids, and advised the farmers on the pest management.

At ICRISAT Center, we continued observations in intercrops to further our understanding on pests and parasitoids. Light trap studies were continued, but more emphasis was given on analysing the data for the effects of environmental factors.

Farmers' fields around ICRISAT Center were surveyed during summer months to build-up upon our experiences on off-season survial of *H. armigera* at and around the Center.

ON-FARM RESEARCH

This year, on-farm testing of the vertisols watershed management technology was in three villages: Taddanpally-Sultanpur in Andhra Pradesh, Begumgunj in Madhya Pradesh, and Parhatabad in Karnataka. We concentrated much at the first site, it being nearer to the ICRISAT Center and more area brought under the scheme.

Taddanpally-Sultanpur (Dist: Medak, Andhra Pradesh)

These are contiguous villages about 45 km west of ICRISAT center. The area under technology testing was increased from 15.42 ha in 1981-82 to 35.24 ha in 1982-83. The following crops/crop combinations were grown by the farmers.

Kharif	Rabi	Hectares
Sorghum/Pigeonpea		15.73
Maize/Pigeonpea		3.48
Mungbean	Sorghum	7.08
Mungbean	Chickpea	0.53
Fallow	Chillies	8.42
		35.24

We studied the populations of insect pests and their parasites on these crops and monitored the farmers' pest control efforts.

Pests and parasitoids

The incidence of insect pests recorded on sorghum are given in Table 1. Insects infestation, in general, was higher than in the last year. Sorghum plants with dead-hearts caused by shootfly Atherigona soccata averaged 3.6 percent and by Chilo partellus 23.7% as against 1.1% and 2.3% by these insects respectively in the previous year. Mythimna separata infestation averaged 8 larvae/100 plants during vegetative stage and 19.7 larvae/100 earheads during grain-filling stage. The aphid Rhopalosiphum maidis was recorded on 25.7% plants during vegetative stage and on 68% plants during earhead stage. Heliothis armigera, as expected, appeared only on earheads. At peak activity period its population was 22 larvae/100 earheads. These larvae were found parasitised 47%, and the parasite recorded was only Campoletis chlorideae.

Head bug Calocoris angustatus was also active. Other earhead pests, Eublemma silliculana and Euproctis subnotata, although present, did not cause any appreciable damage to the crop. There appeared no significant differences between infestations on three sorghum cultivars (CSH 5, SPV 386, and SPV 352) that were grown at the vertisols watershed.

On maize infestation, in general, was similar to that on sorghum except for the absence of shootfly.

On mungbean aphid (Aphis craccivora), sphingid (Acherontia styx and H. armiger were important. Aphids were recorded on about 19% plants. The larval populations of sphingid and H. armigera averaged 3.7 and 3.8 per 100 plants respectively during July through August. In one of the fields, more than 20% defoliation was recorded mainly

due to the larvae of sphingid. H. armigera larvae were parasitised mainly by the nematode Ovomerm a albicans. This parasite emerged from 18% (n=100)of the total larvae collected from this crop.

The insects pests on pigeonpea were studied during flowering and podding. H. armigera eggs and larvae, pod damage by different major pod feeding pests, and yields of pigeonpeas recorded at the watershed are given in Table 2. Heliothis activity peaked in the first fortnight of November, with an average of 102.8 eggs and 38.7 larvae/10 plants. A pigeonpea cultivar ICP 1 suffered relatively more infestation of H. armigera, both in sorghum and maize intercropped systems, than a pigeonpea cultivar ST 1. However, the pigeonpea ST 1 suffered more damage by podfly Melanagromyza obtusa and hymenopteran pest Tanaostigmodes compared to the pigeonpea ICP 1. Three pheromone traps that we operated to monitor H. armigera in this area, caught more numbers of moths in December, following the field infestation by 2-3 weeks. Monthly catches from June 1982 through February 1983 were 4,90,107,,231,57,174,887,651, and 21 respectively.

Egg parasitism, as expected, in H. armigera was nil. Only large larvae (4-6 instars) were parasitised, and parasites emerged were dipterans Carcelia illota, Goniophthalmus halli, and Palexorista solennis. The level of parasitism averaged 6.3% (n=575).

In rabi, sorghum suffered little damage, aphids stunting the growth of some plants. Chillies had no problems. Chickpea, however, suffered some damage due to H. armigera. Hymenopteran parasite Campoletis chlorideae was mainly active, and it parasitised over 40% of the larval population of H. armigera on sorghum and chickpea.

Table 1 : Insect infestation, and yields of sorghum recorded at Taddanpally-Sulthanpur Vertisols watershed, 1982-83.

Crop Systems	On 35-42 days old crop				On 49-56 days old crop		On 91-97 days old crop		H.armigera larval parasitism (%)	Yield/ ha (kgs.)
	Shootfly DH (%)	Chilo DH (%)	Plants with aphids (%)	Mythimna larvae/ 100 plants	Mythimna larvae/ 100 ear heads	Plants with aphids (%)	Ear head with Calicoris bugs (%)	H.armigera larave/100 ear heads		
Sorghum(CSH 5)/ pigeonpea	3.0	23.0	14.0	12.0	28.0	69.0	36.0	12.0	40.0	2089
Sorghum(SPV 386)/ pigeonpea	4.0	27.0	47.0	5.0	18.0	78.0	29.0	17.0	47.0	1952
Sorghum(SPV 352)/ pigeonpea	4.0	21.0	16.0	7.0	10.0	7.0	40.0	38.0	53.0	1258
Mean	3.6	23.7	25.7	8.0	19.0	68.0	35.0	22.3	36.7	1766
S.E. ± (M)	1.73	12.49	14.98	3.51	3.51	34.59	9.5	14.93	9.54	849.4

Average of 2 replications. DH : dead-hearts

Table 2 : Heliothis armigera infestation, pod damage analysis, and yields of pigeonpea recorded at Taddanpally-Sulthanpur Vertisols watershed, 1982-83.

Crop Systems	Pest (No.)/10 plants at peak activity		Percent pod damaged by* (Mean)				Total insect damage*	% loss in wt. of total seeds*	Yield/ ha (kgs.)
	Eggs	Larvae	Borer	Podfly	Hymenoptera	Bruchid			
Pigeonpea (ICP 1)/Sorghum	85.5	33.0	77.2	8.2	2.4	0.2	82.6	68.8	180
Pigeonpea (ST 1)/Sorghum	84.0	25.0	52.5	20.7	6.1	0.3	72.9	51.8	220
Pigeonpea (ICP 1)/Maize	137.5	58.0	70.7	9.6	2.0	0.3	78.2	63.7	215
G. Mean	102.3	38.7	66.8	12.9	3.5	0.2	77.9	61.4	205
S.E ± (M)	46.21	11.59	2.15	0.69	0.51	0.19	1.76	1.46	73.2

Average of 2 replications. *Based on 25 plant analysis.

plant protection :

Crops except the pigeonpea did not require any insecticide protection, for the insect pests were not so serious to cause economic losses. On pigeonpea, as expected, H. armigera became serious and took a heavy toll of the crop in the fields which were not properly treated. As in the last year, DDT wettable powder was made available to the farmers by the Deptartment of Agriculture on 50% cost subsidy. Motorised knapsack and hand-operated knapsack sprayers were at the disposal of the farmers. As in the last year, farmers did not take much interest in application of insecticides despite our advising them through the Deptartment of Agriculture. They sprayed their crops as and when they had a time to spare. This is because most of the farmers of the watershed has wet-land wherein they had main interest to grow rice. Many farmers did not undertake second spraying although they were advised for it, while those who did it were quite late in action. Insecticides used in different fields of pigeonpea, costs of applications and yields of crops are given in Appendix 1.

We conducted a demonstration trial on insecticide application in pigeonpea in one of the farmers' fields to educate the farmers on proper ways of achieving the good results. We selected a field with three equal blocks (0.6 ha approx.), and made the owner farmer to apply insecticide using the motorised knapsack, hand-operated knapsack, and CDA sprayers, one sprayer assigned to one block. We asked the farmer to use only endosulfan (Thiodon) @ 2 litres/ha, and to spray the crop when we advised. The farmer sprayed the crop when we recorded more than 10 eggs and/or 3-5 small larvae (3-5 mm long)/plant in our weekly counting that we did on randomly selected

plants. The farmer obtained good control of H. armigera and got very good yield. The pod damage and yield recorded in the trial compared with average situation in other farmers' fields are given in Table 3.

This trial was an eye-opener to the farmers' of the area, and was an attraction to the passers-by. Farmers of the surrounding area also visited this trial and got themselves apprised of the ways of achieving such results. The CDA sprayer's convenience in insecticide application in pigeonpea was well recognised by all the farmers. The practical attributes of the sprayers studied during the trial are given in Table 4.

This trial, not only confirmed the results of our similar trial at ICRISAT Center in the earlier year (this was, however, in the sole crop), but also convinced us of the necessity of such demonstration elsewhere.

Begumganj (Dist: Raisen, Madhya Pradesh)

This village is 1180 km north of ICRISAT Center near Bhopal, the capital city of Madhya Pradesh. Here, in collaboration with the State Department of Agriculture, 23.8 ha vertisols watershed was under technology testing.

The following crops/crop combinations were taken by the farmers.

Kharif	Rabi	Hectares
Sorghum/Pigeonpea		9.4
Soyabean/pigeonpea		2.8
Soyabean	Chickpea + mustard	2.0

Table 3 : Pod damage and yield from the trial on the comparison of sprayers on the pigeonpea intercropped with sorghum at Taddanpally-Sultanpur Vertisol watershed, 1982-83.

	Percentage of pods damaged by				Total insect damage	Yield (kg/ha)
	Borer	Podfly	Hym.	Bruchid		
Hand operated knapsack	9.5	8.3	4.5	0.0	21.2	1167
Motorised knapsack	18.9	13.2	5.5	0.0	35.7	1249
ULV sprayer	7.7	11.5	3.4	0.1	21.5	1151
Farmer's field (Average of 9 fields)	71.6	12.7	3.1	0.2	81.7	187

Note : 1. Trial was unreplicated.
2. 2 sprays of endosulfan were given @ 2 L. of 35 EC ha.
3. Each trial block was 0.6 ha.

Table 4 : Comparison of three types of sprayers - a hand operated knapsack, a motorized knapsack mistblower and a controlled droplet applicator - tested on pigeonpea at ICRISAT.

	Hand operated knapsack	Motorized mist-blower	Controlled droplet applicator
Weight of empty sprayer (kg)	6.2	12.5	1.1
Weight of full sprayer (kg)	21.5	25.0	1.6
Spray mix required (l/ha)	500	250	4
Fillings required/ha	33	20	8
Time required for spraying:			
(a) Sole pigeonpea (hrs/ha)	33	6.0	3.5
(b) Intercropped pigeonpea (hrs/ha)	21	4.5	2.0
Persons required	2	2	1
Other materials required	-	Petrol and Oil	Batteries Sugar

Soyabean	Linseed	2.0
Soyabean	Wheat	7.2
Soyabean	Lentil	0.4
		23.8

Pests and parasitoids

Sorghum suffered a lot in the first year of the technological testing due to unusual heavy rainfall which at a time continued at-a-stretch for three weeks in August. The left over sorghum suffered 0.3% dead hearts by shootfly A. soccata and 6.5% dead hearts by C. partellus. In earheads only H. armigera and E. subnotata appeared in considerable numbers. H. armigera larvae (n=50) on soghum were found parasitised 22% by C. chlori-eae, 4% by Eriborus argenteopilosus, and 2% by C. illota, only. The parasitism due to E. argen eopilosus was recorded at higher level for the first time on sorghum in our studies. At ICRISAT center and in the farmers' fields in southern parts of India, we have always recorded it below 1% .

Soyabean, although grew little stunted, did not suffer any appreciable damage by insect pests. Soyabean girdle beetle Oberia brevis which is reported to be important on this crop in most years, did not appear probably because of the unusual high rainfall.

Pigeonpea, although grew slow initially, came up very well at flowering and podding. During vegetative stage, insects - Etiella zinckenella, Adisura stigmatica and Lampides boeticus appeared on the crop, but were not of much concern. As expected, H. armigera

appeared on pigeonpea during flowering through podding, but was not as serious as we do normally record it in southern India. Its activity peaked to only 4.8 eggs and 5.2 larvae/10 plants (Table 5). Surprisingly, in this area we found higher rate of parasitism 24.5% (n=200) in the larvae of H. armigera, that too largely (95%) effected by the hymenopterans and mainly by E. argenteopilosus. This is in contrast to the observations made at ICRISAT center and in other southern parts of India, where parastism was found always below 15%, and that too mainly effected by dipterans, particularly C. illota.

On chickpea, which is a common rabi crop of this area, H. armigera appeared right from the vegetative stage of the crop. The infestation appeared apparently higher on chickpea in this area than that is normally seen in southern India. This is probably because in northern India chickpea becomes available to H. armigera before pigeonpea reaches to the vulnerable stage, that is flowering. By the time pigeonpea becomes available, the insect is well established on chickpea and tends to shift a little. On chickpea, only 4% of the small larvae (1-3 instars) were found parasitised, that too exclusively by E. argenteopilosus. This is again in contrast to the situation in southern India where over 50% parasitism is generally and exclusively by C. chlorideae.

On wheat, linseed, and lentil insects activity was minimal. H. armigera appeared rarely on any plants of linseed and lentil.

To know the important insects of this area, we operated a light trap in the State government seed-farm, which is adjacent to the vertisols watershed, and recorded the catches of insects that were

Table 5 : Heliothis armigera infestation, pod damage percentages by different pod pests and yields of pigeonpea, Begumganj Vertisols watershed, 1982-83.

Crop Systems	Pest (No.)/10 plants at peak activity		Percent pod damaged by (Mean)[a]				Total insect damage	% loss in wt. of total seeds	Yield/ ha (kgs.)
	Eggs	Larvae	Borer	Pod fly	Hymenoptera	Bruchid			
Pigeonpea/ Sorghum	4.7	5.3	13.5	25.0	0.5	0.02	37.6	14.5	1183
Pigeonpea/ Soyabean	4.9	5.0	14.6	22.9	1.0	0.02	36.0	14.6	1128
G. Mean	4.8	5.2	14.1	23.9	0.7	0.02	36.8	14.5	1155
S.E ± (M)	0.3	0.07	5.09	4.28	0.04	—	7.99	4.1	145.9

Average of 2 replications. *Based on 25 plant analysis.

Table 6 : Monthly catches of Helicoverpa armigera and Spodoptera litura in light and pheromone traps at Begumganj, 1982-83.

Month	LIGHT TRAP		PHEROMONE TRAP	
	H. armigera	S. litura	H. armigera	S. litura
August	44	173	3	448
September	47	456	52	2284
October	40	1227	101	7088
November	304	833	2970	5448
December	257	25	4271	1319
January	201	36	3011	1585
February	191	58	3327	1407
March	2116	63	612	677

coming in large numbers. In addition, pheromone traps of H. armigera and Spodoptera litura were operated both at the seed farm and the watershed. The catches of of these two noctuids both in the light and pheromone traps are given in Table 6. S. litura, although was caught in large numbers in traps, did not appear on any of the crops of the watershed and surrounding area. We suspect, this could be because of migration of this insect from other area but this needs to be investigated by the entomologists. H. armigera was also trapped apparently in large numbers in pheromone traps at this location, although its infestation on crops was lower than at other locations. This indicates, most probably, that the pheromone traps are more efficient when the infestations rare low.

Plant protection

The plant protection in principle envisages protecting the crops from weather aberrations and pests. Unfortunately, we had no control over the unusual continuous rainfall that was received in the kharif. However, the pigeonpea component of our crop system fared well even under this unfavourable conditions and provided the farmers a reasonable return.

Insect activity increased following the rain. We requested the Department of Agriculture to make available the insecticides and application appliances to the farmers well in advance. The farmers' were given 30% subsidy on the cost of insecticides, and appliances were provided for use without any rent. The detailed account of insecticide used on pigeonpea, costs of applications and yields of the crops are given in Appendix 1. In pod analysis, the percent pod

damage by podfly was found more compared to that by H. armigera (Table 5.). The insect induced yield losses were around 15%.

On sorghum some farmers applied one spray of insecticide, phosphamidon (Demecron), against earhead pests and obtained some yields. Soyabean did not require any protection, for it was apparently free from insects. Chickpea, as expected, was attacked by H. armigera, and the farmers controlled this pest by applying insecticides.

We recommended only one spray on pigeonpea, but one of the farmers did not spray his crop, while a few enthusiasts undertook two or three sprays. All the farmers, in general, obtained good yields and those who sprayed the crop got higher returns.

On chickpea 1-2 sprays of phosphamidon or endosulfan were done by the farmers, and they obtained good yields, in the range of 6-8 quintals/ha. Pod damage was exclusively by Heliothis and it averaged 6.4%.

Farhatabad (Dist: Gulburga, Karnataka)

This village is about 250 km west of ICRISAT center. The technology testing was undertaken over 11.42 ha. The following crops/crop combinations were grown by the farmers.

Kharif	Rabi	Hectares
Pigeonpea		0.85
Maize/pigeonpea		0.35
Groundnut/pigeonpea		1.85

Sesamum/pigeonpea		0.30
Greengram	Sorghum	6.15
Blackgram	Sorghum	0.50
Fallow	Sorghum	4.80
Blackgram	Safflower	0.50
Fallow	Safflower	1.20
		16.00

At this location we monitored only H. armigera that too mainly with pheromone traps. The monthly catches obtained in two traps, that were operated at this watershed from July 1982 through May 1983, were 12, 86,314, 566, 254, 628, 420, 90, 8, 4, and 2 respectively. Moths started coming in large numbers from september, when pigeonpea began to flower, and continued until febtuary when pigeonpea was harvested. After that the catches in traps decreased.

This area has traditionally been one of the most insecticide treated pigeonpea areas in India. In this first year of our on-farm research, we only studied the farmers' method of insecticide application. The farmers applied insecticides from the budding stage at an interval of 10-12 days without bothering to look for insects on the crop. They ended up with 6-7 dusts/sparys on their crops (Appendix 1). Application was mainly done by using a foot sprayer which was transported in bullock-cart through the crop while spraying. The farmers got good yields, but the inconvenience and the cost of application were high. The total pod damage percentage, recorded after harvest, averaged 20.5 percent with insect induced losses

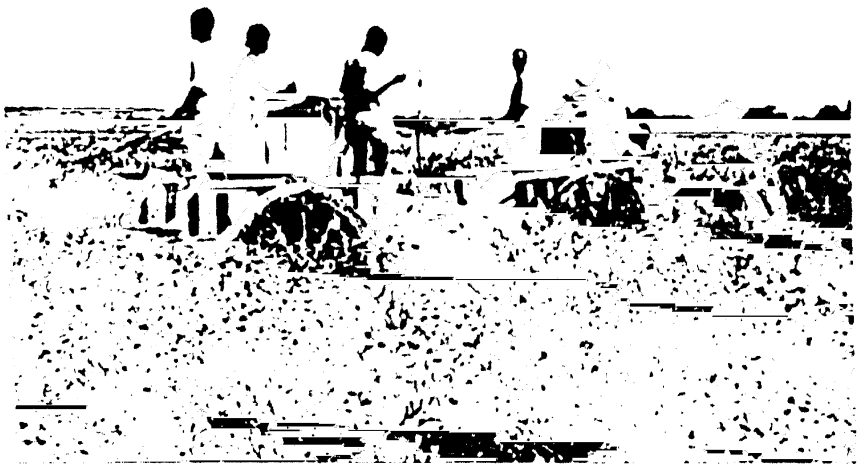
estimated at 80.4 kg.

Other crops grown at the watershed did not suffer much insect damage, and produced optimum yields. This was, however, reported to us by Dr. Y. Nishimura who co-ordinated the on-farm research at this watershed during 1982-83.

LIGHT TRAP STUDIES :

Insect monitoring with light traps at ICRISAT Center dates back to 1974, and at other locations in India in our net-work to 1979. While, at ICRISAT Center, we have continued trapping insects by shifting, adding or substracting the number of traps, the trapping at other locations, which is being looked after by scientists in National Programs, has reportedly been becoming difficult because of irregular electric-power supply and thefts of electric bulbs. We have been getting data regularly only from five locations, two of which are ICRISAT substations. Fortunately, we have an access to H. armigera light trap data that are being collected by national scientists at Jabalpur and Coimbatore since before we started the work on light traps. The traps employed at these locations are not 'Robinson's modified traps, the type we have been using in our net-work.

The pheromone trapping net-work for H. armigera initiated since 1980 by our Pulse entomology sub-program is, however, now well established covering many locations in India, Pakistan, Sri Lanka and Bangla Desh. This trapping is preferred by scientists for it involves only one insect species and does not require a source of electricity.



A traditional practice of spraying the pigeonpea crop in Karnataka state (India). A bullock cart is used to carry a spray liquid drum and a sprayer. One man operates the sprayer and others direct the spray onto the top of the crop. A lot of crop is damaged and no good coverage is obtained.

Table 7. Annual catches of some important legume borers, cereal and cotton pests and the *Spodoptera* complex in a light trap on the Vertisol watersheds, ICRISAT Center (1978-83)

Season	ANNUAL CATCH (No).													
	Lepidopteran legume borers					Cereal pests			Cotton pests			*Spodoptera* complex		
	Adisura martinalis	*Adisura stigmatica*	*Etiella zinckenella*	*Heliothis armigera*	*Maruca testulalis*	*Chilo partellus*	*Sesamia inferens*	*Sesamia calamistis*	*Dysdercus* sp.	*Earias insulana*	*Earias vittella*	*Spodoptera exigua*	*Spodoptera litura*	*Spodoptera mauritia*
1978-79	990	4212	6650	10633	1877	4088	12775	2097	13934	205	22732	7696	4406	1658
1979-80	343	1713	5385	18019	955	17882	11705	208	17492	325	19125	17546	3401	1333
1980-81	268	1586	7549	7653	1092	18635	7307	280	59345	290	13770	14294	10491	1124
1981-82	2835	7196	13002	37524	1000	4154	5603	186	4924	431	5610	5010	7708	1987
1982-83	813	1511	3982	15944	2470	9490	3432	323	5245	372	6733	6042	3601	1479
Average Annual Catch (No.)	1050	3244	7314	17955	1479	10850	8164	619	20188	325	13594	10118	5921	1516

Light trap catches in 1982-83

The catches of important insect pests recorded over the past five years in light trap at our Vertisols watershed are given in Table 7. This year legume borer pests were caught in lower numbers than in 1981-82, but not lower than in the three years before 1981-82. The catches of Cereal pests C. partellus and H. separata increased compared to those in 1981-82, but over the years there appears no major change in the activity of these insects. Dysdercus spp and Earias spp, the insects important on cotton, were caught without any appreciable decrease over the catches in 1981-82; but there appears in general a declining trend in catches over the years. Spodoptera catches remained more or less same over the years except for 1979-80 and 1981-82 when S. exigua was caught in high numbers. S. litura activity, although increased in 1980-81, has declined over the past two years.

Catches of parasites and predators, did differ much over the past five years except for slight shift in catch periods in some cases. For instance, Bracon sp a parasite of H. armigera, was obtained more in September than the usually in October.

Some important observations on light trapping

We have a huge data available on light trap catches and field counts of insects at ICRISAT Center. We are now attempting a series of analyses so as to say how light trap, and in some cases pheromone trap could be used in pest management. The work in this direction has already been initiated for H. armigera with an active involvement of

our Pulse entomology sub-program, and attempts are being made do the same for other important insect pests. Some of the basic observations which were long over due to be described, are given below.

1) Effect of trap location on catches :

It is well documented in our earlier reports that we, worked with only one light trap at ICRISAT Center between 1974-1976 and there after set two more traps, thus making a total three. Our first trap was outside ICRISAT boundary, near the northern fence until 1979, when it was moved about 200 meters to bring it inside the fence at a location called RA1. The other traps, since operated, are at the same locations - the Manmool and the Vertisols Watershed (Appendix 2). Average monthly catches of H. armigera over 4 consecutive years of trapping at these locations are given in Table 8. There appears a very wide variation in catches at different locations, and this calls for the understanding of the surroundings of these locations. The outside location called "CIB" was in the trees and a few office and residential buildings, and never had any crop in immediate proximity. The RA1 location is surrounded by lakes on two sides, and remains cropped around during the crop seasons. The Vertisols watershed location is at about the centre of the ICRISAT main-land, and has a huge crop area around. The manmool location is towards south in the main land, and has a lake and a few raised structures around, and it remains cropped on most sides during the crop seasons.

Table 8: Average monthly catches of *H. armigera* in light traps at different locations of ICRISAT Center (Averages are over a set of 4-years of continuous monitoring at each location).

Month	ICRISAT Center light trap locations			
	C.I. Building	RA-I	Manmool	Vertisols watershed
June	19.8	4.3	13.8	2.8
July	17.5	2.5	23.0	125.0
August	55.8	35.8	142.8	2449.5
September	326.8	115.0	368.5	2959.8
October	200.5	36.8	251.3	1564.0
November	1251.0	262.8	974.3	4207.0
December	7447.3	223.8	690.3	6482.3
January	573.3	44.0	127.3	1039.0
February	186.8	26.0	54.5	485.0
March	248.0	38.0	101.8	481.0
April	863.5	149.8	181.0	449.5
May	334.3	38.5	28.8	41.0
Mean	960.4	81.4	246.4	1690.5
SE ± (M)	336.8			

Table 9: Average daily catches of H. armigera in light and pheromone traps against different wind velocities between 0.00 - 06.00 hrs of the day, ICRISAT Center, (June 81 - June 83).

Wind velocity km/hr (0.00 - 06.00) range	Frequency (No. of nights)	Light trap locations			Pheromone trap locations*		
		VWS	Manmool	RAI	VWS	Manmool	RAI
1 - 5	298	100.6	8.4	3.6	8.8	3.9	2.0
6 - 10	191	81.3	5.4	2.3	13.4	5.5	3.2
11 - 15	108	45.1	3.2	0.6	7.4	2.6	1.5
16 - 20	66	34.5	1.5	0.3	2.8	1.4	1.1
21 - 25	39	11.7	0.6	0.3	1.3	1.4	0.6
26 - 30	19	24.6	0.4	0.1	1.5	0.9	0.5
31 - 35	7	0.6	0.3	0.1	0.2	0.1	0.6
36 - 40	2	0.0	0.0	0.0	0.8	2.8	0.5

*Averages of 2 replications

More catches at Vertisols watershed, moderate at manmool and low at RAl, therefore, finds an explanation by the extent of cropped area around the trap; but the surprising thing is the high catches obtained at 'CIB, the location which never had any crops around. We wonder whether trees had any thing to do with the attraction H. armigera at this location. Another possibility might be that the flood-lights of the office and residential buildings were adding to the intensity of illumination from the light trap and bringing around more H. armigera. These aspects certainly need to the noted, and discussed in scientific forums.

Around June, Which follows a closed-season (April-May) at ICRISAT Center when all crops are removed, the Vertisols watershed light trap catches relatively fewer moths. This is because the Vertisols watershed area during this period is more cleaner than the RAl and Manmool areas where H. armigera larvae survive feeding on the weeds growing around the lakes and buildings. The insect hosts intensity and extensivity, thus need to be studied in relation to the catches in the light trap.

2) Light trap catches and environmental factors :

We have been attempting to work out the corrections for the various environmental factors that affect the light trap catches. Our attempt of correlating the daily and weekly catches of H. armigera with the corresponding enviromental factors - rainfall, temperature, humidity, wind velocity, has given us very poor correlations (r= 0.2 to 0.3), that too mostly negative. This indicates that there is a need to fractionate the data for different periods of activity of

insect. This is now being attempted in collaboration with our Pulse entomology sub-program, which further seeks the help of the Tropical Development and Research Institute, London.

H. armigera is mostly trapped between 24.00 hrs.-06.00 hrs. We arranged the 1981-83 light and pheromone trap data of H. armigera as per the wind velocity records between this period, and found that the light trap catches more moths when the wind velocity is between 1-5 km/hr and the pheromone trap when it is between 5-10 km/hr (Table 9). High velocities reduce catches, probably by hindering the flight of moths towards the trap.

3) Light trap catch, time of night, and the moonlight :

Insect catches in light trap are greatly affected by the time of the moon rise and set, its illumination and angle of elevation to the earth. These effects are well documented in the literature, but there is a great need to specify these effects for the trap and the trap location.

Average daily catches of H. armigera for the ICRISAT Center trap locations and the Hissar trap (ICRISAT Center in North) are given in Fig 1. It is really surprising why there appears no reduction in catches around the full moon at Hissar. We have, so far, no answer for this surprising observation. At ICRISAT Center, reduction in catches with the moon illumination is recorded at every location although the rate of decline varies considerably. We are still working on the complicacies of standardising the moon effect.

Fig. 1 : Effect of the moon illumination on the light trap catches of Heliothis armigera

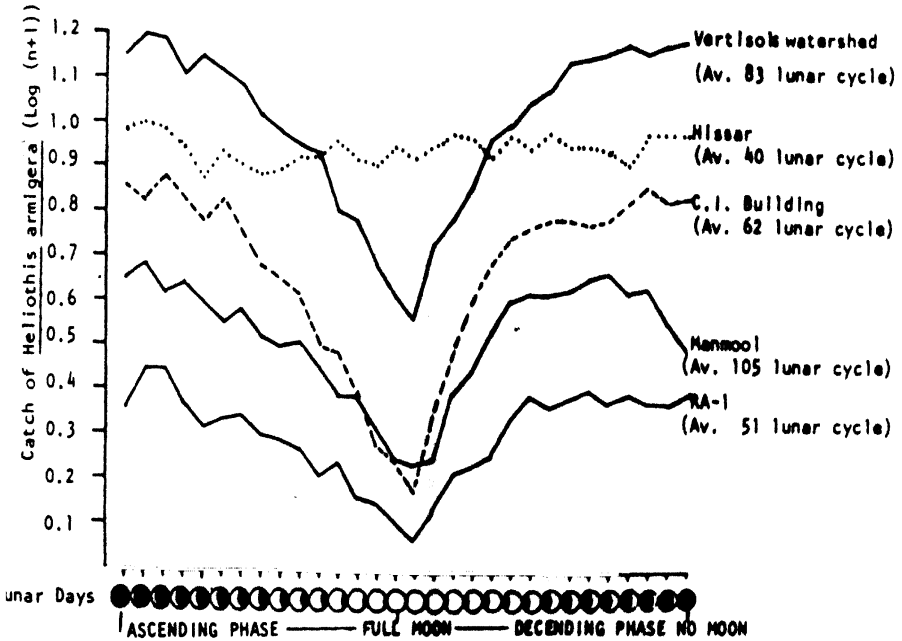
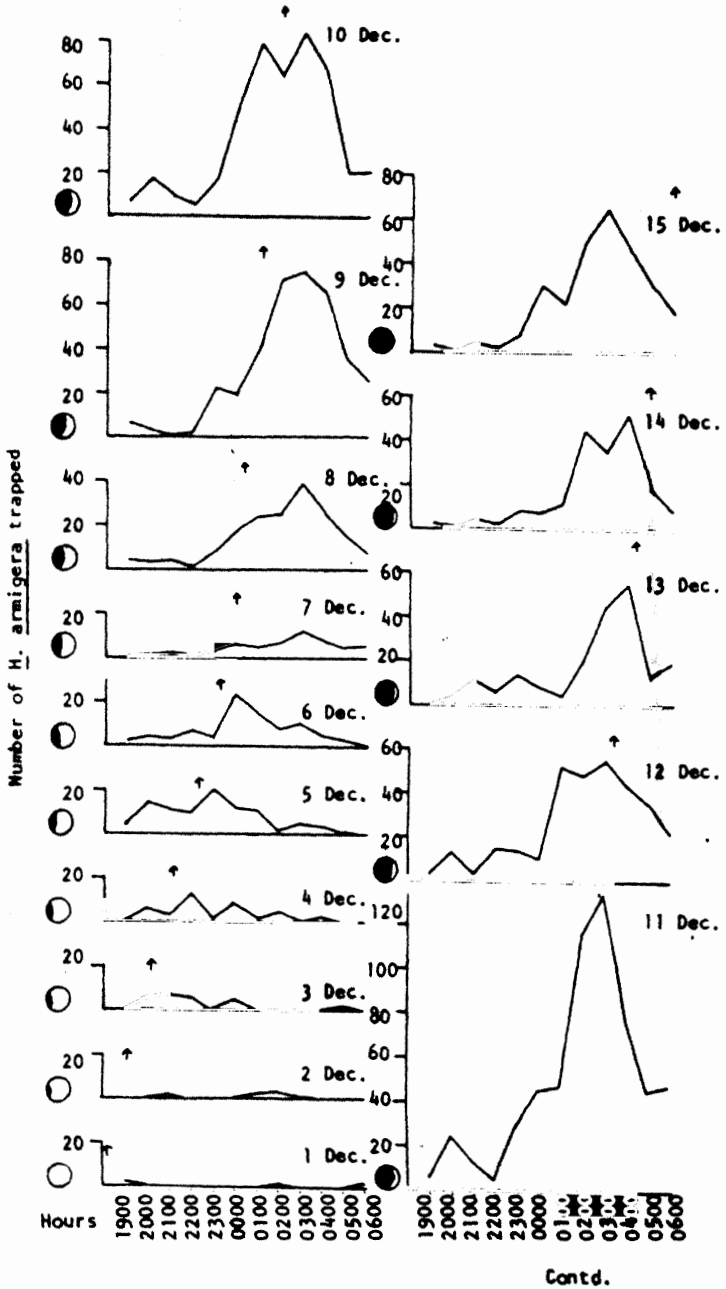


Fig. 2: Hourly catches of H. armigera in light trap at Vertisol watershed in relation to the visible crescent and the time of rise and set of the moon during lunar cycle, 1-30 Dec. 1982, ICRISAT Center.



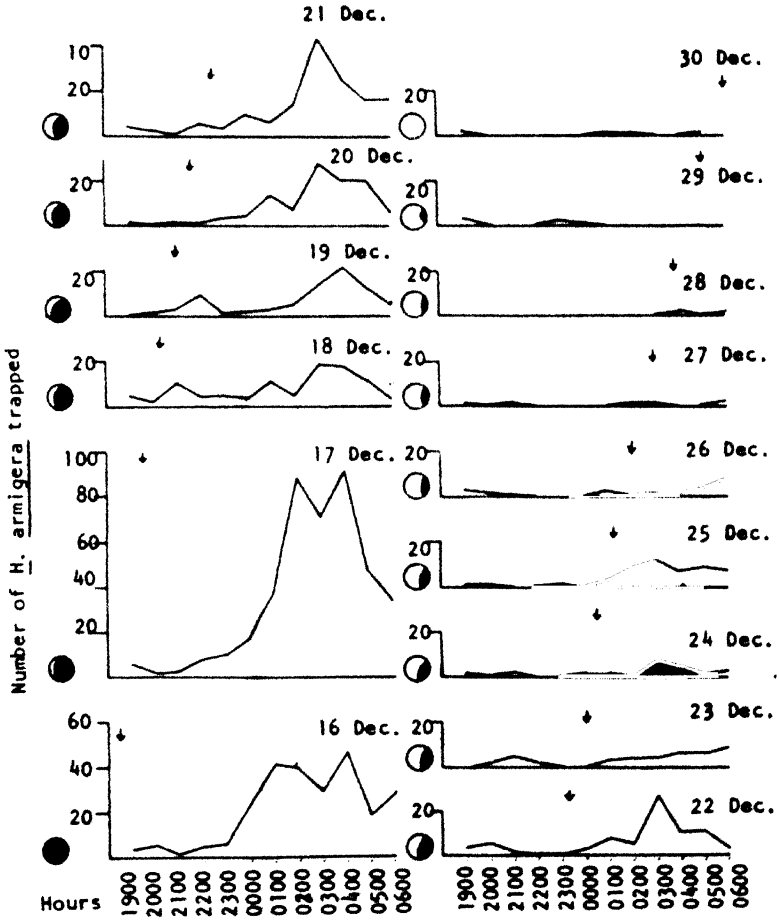

21 Dec.
30 Dec.
20 Dec.
29 Dec.
19 Dec.
28 Dec.
18 Dec.
27 Dec.
17 Dec.
26 Dec.
25 Dec.
24 Dec.
16 Dec.
23 Dec.
22 Dec.
Number of H. armigera trapped
Hours
1900
2000
2100
2200
2300
0000
0100
0200
0300
0400
0500
0600

Table 10: Percent parasitism on Heliothis armigera (Hb.) recorded on cultivated crops and weed hosts, in Andhra Pradesh, Maharashtra and Karnataka 1977-83.

Crops	Total egg collected (No.)	% egg parasitised (Max.)	Total larvae collected (No.)	% larvae parasitised (Max.)
Cereals				
Maize	3558	76.0	2230	45.0
Sorghum	27987	87.0	31688	60.0
Pearl millet	2769	60.0	931	47.0
Legumes				
Chickpea	4028	0.0	44417	70.0
Cowpea	1048	37.0	5991	45.0
Groundnut	2785	44.0	5986	42.0
Pigeonpea	24876	0.2	76446	40.0
Pea	Nil	-	11	63.0
Hyacinth bean	Nil	-	68	46.0
Mungbean	-	-	415	8.0
Soyabean	-	-	133	9.0
Oilseed/fibre				
Linseed	11.0	0.0	60	20.0
Safflower	612	32.0	2573	60.0
Sunflower	159	2.0	96	40.0
Cotton	150	38.0	-	-
Vegetables				
Onion	-	-	100	8.0
Okra	676	0.1		
Tomato	440	2.3	1685	26.0
Weeds				
Acanthospermum hispidum	175	35.0	2072	35.0
Asteracantha longifolia	-	-	28	27.0
Clitoria ternata	-	-	130	2.0
Cardiospermum halicacabum	61	0.0	35	14.0
Datura metel	2690	11.0	5142	40.0
Gompherana celosioides	1894	3.0	5000	62.0
Gynandropsis sp.	177	0.0	1679	55.0
Martynia annuva	-	-	25	20.0
Phyllanthus maderaspatensis	-	-	46	12.0
Sesbania sp.	100	16.0	210	36.0

To get some idea about the effect of the time of the moon rise and set and in general the night period for maximum catches of H. arm cera, we recorded hourly catches in light and pheromone traps daily on a lunar cycle in December 1982. The catches, the time of the moon rise and set, and its cresent visible on the horizon, recorded during this period, are shown in Fig. 2. There appeared varying trends in catches each night, but in general maximum catches were recorded between 02.00-05.00 hrs.

SURVEY

We concluded our a-five year survey of biotic control agents of H. arm cera in 1981-82. We collected H. armigera eggs and larvae from the farmers fields of Andhra Pradesh, Maharashtra and Karnataka, mainly during November to January when H. arm cera is generally more active, and reared these further in the laboratory to record the parasites. With this survey, we concluded that H. armigera is parasitised in egg stage by 4 insect and in larval stage by 28 insect and 2 mermithid species. The parasitism varies widely with the host crops of the pest (Table 10). In general, cereals encourage the egg and small larval (1-3 instars) parasites which belong to Hymenoptera, and legumes the large larval (4-6 instars) parasites which belong to Diptera. We have further, observed that H. arm cera is preyed upon by as many as 21 insect predators.

With this survey, although our collection of H. arm cera came from a wide variety of crops and weeds, we could not found much about the survival of the pest and its parasitism during off-season. To improve our understanding on this, for the past two years, we have

been studing H. armigera larvae in the farmers' fields within a radius of 100 km from ICRISAT Center. We collect these larvae and study the parasitism in the laboratory. Around Hyderabad, a city 30 km from ICRISAT Center, tomato crop is largely grown during the summer months (April-June) by the farmers under irrigation, for during this period high prices prevail for tomato in the markets. This crop, sustains high population of H. armigera during these months and act as an important carry-over source of the pest between main crop seasons, rabi to kharif.

This year, with a-day trip every week in May and June, we could collect 487 larvae of H. armigera from tomato. The tomato crops were reported sprayed; most farmers spraying the crop at 10-15 days interval. No parasite emerged from our collection. We do not know whether parasites were killed by the insecticide applications or they were inactive because of the hot sun. However, in our continuous hunt for H. armigera until August which prolonged into the mansoon, we recorded 37.5% (n=243) larval parasitism by mermithids and only the beginning of parasitism by C. chlori·eae (0.01%).

About a hundred larvae were also collected from weeds during May-June. They were also not parasitised. Gomphrena celosoides was the important weed supporting Heliot·is during these months.

These observations indicate that the parasites are affected more by high temperatures in summer than the pest. We intend to build up such data for off season survival of H. armigera with a hope that the weak linkages in the carry-over of the pest is known to the plant protectionists so that they hit the pest at the most critical time.

INTERCROPPING STUDIES AT ICRISAT CENTER

This year, we did not raise crops separately, but studied the pests and parasitoids in the crops raised by our cropping systems agronomists. On vertisols, we covered the sorghum/pigeonpea and maize/pigeonpea intercrops, and on alfisols the sorghum/pigeonpea, millet/pigeonpea, and groundnut/pigeonpea intercrops.

Cereals

Cereals ; sorghum, millet, and maize, did not suffer any appreciable damage from insects during seedling stage. In sorghum shootfly A. soccata and stem borer C. partellus caused dead-hearts in less than 2% plants. M. separata infestation was low; averaged 4.1 larvae (range 1-17 larvae)/100 plants on 40±1 day old crops, and it appeared relatively more on maize than on sorghum and millet. Aphid R. maidis was recorded on all the cereals with 30-43% plants infested at 40±1 day of the crop growth. Head bug C. angustatus appeared on more than 25% of sorghum plants at earhead stage. An earhead pest H. armigera was recorded on all the cereals. Its infestation and parasitism at peak activity are given in Table 11. The infestation did not differ much between the cereals. Parasites emerged only from small (1-3 instars) larvae; and parasites, as expected, were only hymenopterans. C. chlridea dominated the sene, and was the only parasite emerged from the collections on the vertisols. However, from the collections on the alfisols, there also emerged a parasite Microchelnus curvima-ulatus from 18% of the small larvae on millet and from 2% of the small larvae on sorghum, and a parasite Temeluc a from 3% of the small larvae on sorghum. Overall

parasitism, as also reported earlier, was higher on the alfisols than on the vertisols. The most interesting observation has been the good association of H. curvimaculatus, which is an egg-larval parasite of H. armigera, with the millet crop.

Groundnut

Groundnut also suffered little from insects. H. armigera eggs and larvae were recorded during early stages of the crop growth, but infestation was low, always below 1 egg and 0.5 larvae/plant. Jassids appeared mainly during early stages of the crop growth; their numbers averaged 2 jassids/plant at the third week of the crop growth. Thrips became active during 5-6 weeks, but their overall population appeared too low to bring-in any appreciable bud-necrosis disease. Only few hairy caterpillars E. subnotata were recorded during 9-10 weeks.

Pigeonpea

Pigeonpea in different crop systems both on the vertisols and alfisols suffered little from insects during vegetative stage. Leaf webber E. critica appeared somewhat more compared to other foliage feeding insects but did cause any appreciable damage to the plants. H. armigera appeared from flower-bud stage and soon became pestiferous damaging several buds, flowers and pods. Its activity grew unabated for the crops were not to be sprayed in the trial. On the alfisols, its activity was at peak during the first fortnight of November while on the vertisols it peaked during the second fortnight of November. The peak infestation of H. armigera, pod damage by different pod feeding insects assessed after harvest, and yields of

Table 11 : Insect infestation, and yields of sorghum, maize, and pearl millet recorded at Research Center, 1982-83.

Crop systems	H. armigera larvae at peak activity	Percent parasitism in 1-3 instar larvae of H. armigera			Total larval* parasitism of H. armigera (%)	Yield /ha (kgs.)
		Campoletis chlorideae	Micro-chelonus survina-culatus	Tenuicha sp.		
			VERTISOLS			
Sorghum/ pigeonpea	17.5	58.1	-	-	45.0	3650
Maize/ pigeonpea	9.5	31.3	-	-	25.0	3178
Mean	13.5	44.7	-	-	35.0	3414
S.E. ± (M)	3.54	10.15	-	-	7.07	141.4
			ALFISOLS			
Sorghum/ pigeonpea	15.5	75.0	2.0	3.0	71.0	3078
Pearl millet/ pigeonpea	10.0	78.0	18.0	0.0	96.0	2471
Mean	12.8	76.5	10.0	1.5	83.5	2775
S.E. ± (M)	5.3	17.68	-	-	0.71	115.9

Average of 2 replications.

* Larval collection 100, with 80-90 small larvae in all cases

Table 12: Heliothis armigera infestation, pod damage analysis, and yields of pigeonpea recorded at Research Center, 1982-83.

Crop Systems	Pest(No.)/10 plants at peak activity		No. of pods analysed	Percent pod damage by (mean)*				Total insect damage	%loss in wt. of total seeds	Yield/ ha. (Kgs)
	Eggs	Larvae		Borer	Podfly	Hymenop -tera	Bruchid			
				VERTISOLS						
Pigeinpea/ Sorghum	56.0	23.5	5646	64.2	10.7	10.6	0.6	78.4	62.4	596
Pigeonpea/ Maize	73.0	27.0	6562	56.7	10.9	10.1	0.7	71.7	57.2	935
Mean	64.5	25.3	--	60.4	10.8	10.3	0.6	75.0	59.8	765
S.E.±(M)	0.71	6.72	--	4.4	0.25	1.66	0.25	5.7	7.25	63.6
				ALFISOLS						
Pigeonpea/ Sorghum	42.0	27.0	7819	48.4	10.7	1.7	2.6	60.3	42.1	682
Pigeonpea/ Pearl millet	48.5	25.5	3790	84.4	4.5	2.2	1.6	89.1	78.2	325
Pigeonpea/ Groundnut	42.0	29.0	4703	71.5	10.7	3.9	1.2	81.0	69.1	390
Mean	44.2	27.2	--	68.1	8.6	2.6	1.8	76.8	63.1	466
S.E.±(M)	16.73	1.04	--	4.9	0.4	1.68	0.3	4.01	2.83	188.2

Averages of 2 replications

*Based on 25 plant analysis.

pigeonpea obtained in different crop systems are given in Table 12.

There appeared no significant differences in H. armigera infestation and pod damage by different groups of pod feeding insects in pigeonpea between the sorghum and maize intercrops on the vertisols. However, on the alfisols the pigeonpea pod damage by borer, which includes besides major damage by H. armigera the damage by E. zinckenella, E. atomosa and other pod borers, was significantly higher in the millet and groundnut intercrops than in the sorghum intercrop. This observation when critically studied with other observations, the difference appeared largely because of the pod-set which was poor in the pigeonpea intercropped with millet and groundnut. From 25 pigeonpea plants (5 sets of 5 plants selected randomly in the field) in millet and groundnut systems, a total of 3790 and 4703 pods were obtained respectively as against 7819 pods in sorghum system.

As expected, parasitism of H. armigera in pigeonpea was low both on the vertisols and alfisols. Egg parasitism was nil, and only large larvae (4-6 instars) were parasitised. The parasitism appeared in the range 0-6% (n=100:larvae collected in each system), with the higher record on the groundnut intercropped pigeonpea and the lower record on the alfisols' sorghum intercropped pigeonpea.

We would be studing these intercrop systems again in the coming years particularly on the alfisols so that the above observations could be reaffirmed.

Appendix 1: The details of insecticides used, costs of applications and yields of pigeonpeas at Taddanpally-Sulthanpur, Begumganj and Farhathabad Vertisols watershed (1982-83).

Individual fields and area (ha)	Insecticides and No. of applications	Cost of* insecticide/ ha (Rs)	Labour & ** other cost/ ha (Rs)	Total cost/ ha (Rs)	Yield in Quintals/ ha
	Taddanpally-Sulthanpur (Medak District, Andhra Pradesh)				
1.2	DDT	35.20	46.00	81.20	--
1.03	DDT	52.80	46.00	98.80	2.8
2.51#	Thiodan and Thiodan	320.00	61.50	381.50	11.05
0.98	DDT and Ekalux	246.20	67.00	311.20	0.79
0.7	DDT and DDT	61.60	67.00	128.60	--
2.4	DDT	30.80	46.00	76.80	3.19
0.67	DDT	48.40	46.00	94.40	1.74
1.77	DDT and DDT	37.40	46.00	83.40	2.65
0.8	DDT	28.60	46.00	74.60	5.92
2.75	DDT and Ekalux	94.80	67.00	161.80	1.9
3.0	DDT and Nuvan	52.00	67.00	119.00	1.71
0.8	DDT	28.60	46.00	74.60	--
1.37	DDT	33.00	46.00	79.00	1.1
	Begumganj (Raisen District, Madhya Pradesh)				
2.4	Thiodan	80.00	29.00	109.00	7.18
2.0	Democron and Thiodan	155.00	58.00	213.00	6.96
1.2	Thiodan	48.00	29.00	77.00	8.24
0.8	Thiodan	96.00	29.00	115.00	10.9
0.8	Thiodan and Thiodan	213.50	87.00	300.00	12.76
0.8	Thiodan and Thiodan	180.00	58.00	238.00	14.32
0.4	Thiodan	100.00	29.00	129.00	14.77
0.4	Thiodan	100.00	29.00	129.00	10.47
2.5	n.a.	--	--	--	6.02
0.9	n.a.	--	--	--	6.26
	Farhathabad (Gulbarga District, Karnataka)				
0.85	Cythion, Thiodan, Ekalux, Nuvacron and Nuvacron	460.05	420.00	880.05	13.5
0.35	Ekalux, nuvacron, DDT, Nuvacron, Nuvacron & Nuvacron	451.60	420.00	871.60	8.0
0.25	Cythion, Thiodan, Ekalux, Nuvacron, Nuvacron & Nuvacron	442.00	420.00	862.00	9.3
1.85	Cythion, Thiodan, Ekalux, Nuvacron, DDT, N.cron & N.cron	536.40	490.00	1026.40	9.32

* Cost does not consider subsidy given to the farmers on insecticide.
** Other cost includes hire rate of spray machines, petrol cost etc.,
\# ICRISAT demonstration trial

APPENDIX 2: LIGHT TRAP LOCATIONS AT ICRISAT CENTER.